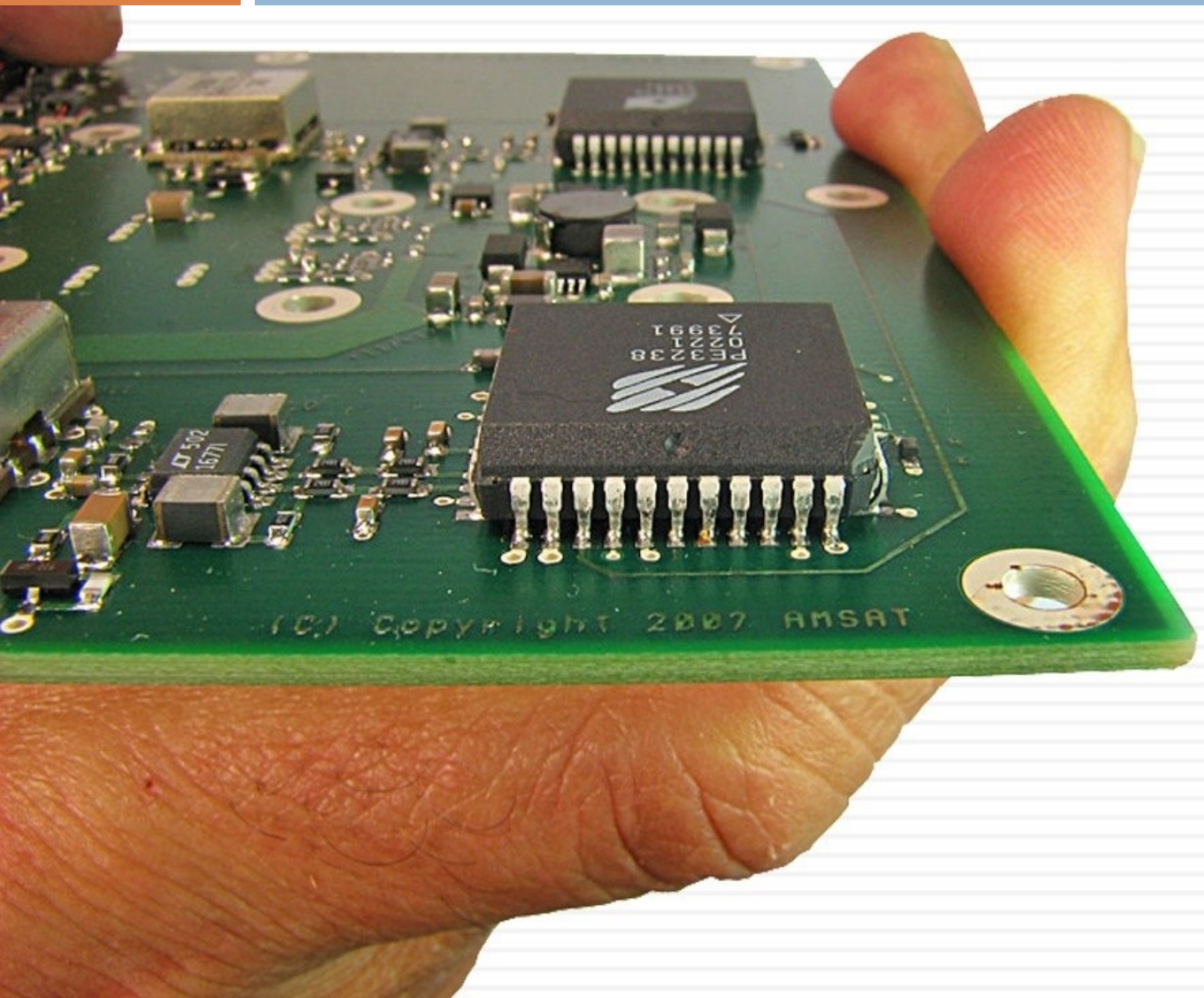
70 cm Receiver



70 cm Receiver

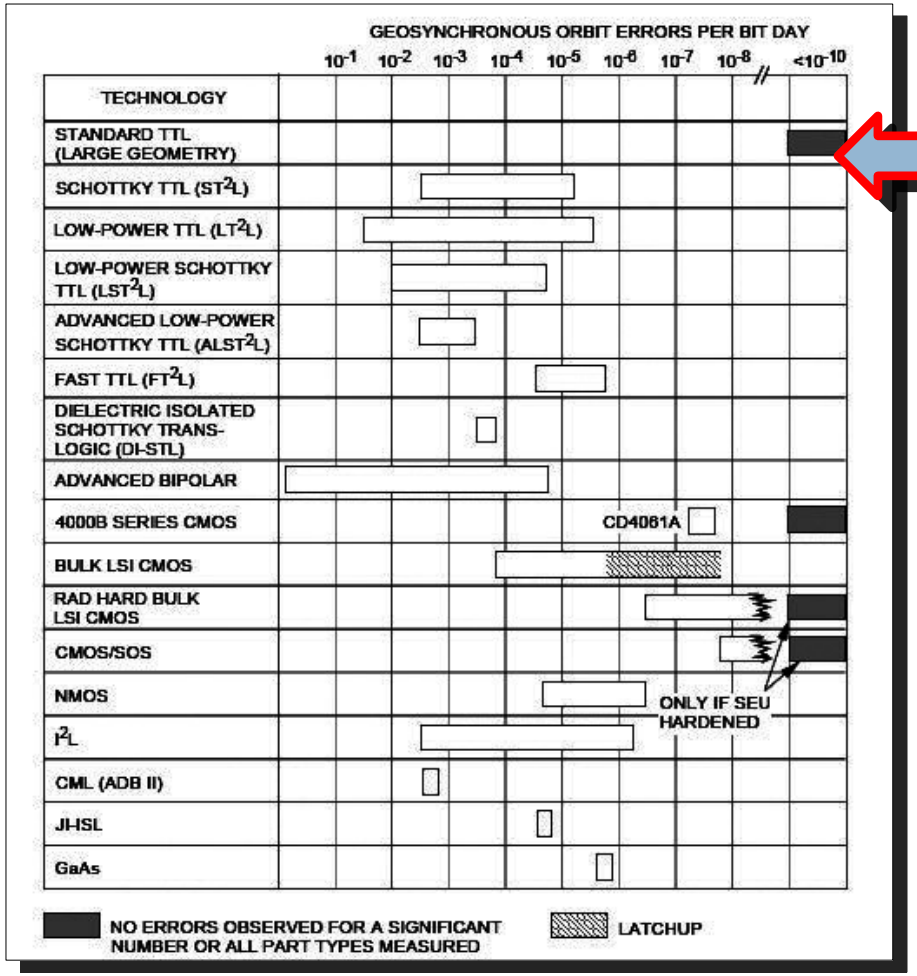
How do we Make Sure That the Sucker Just WORKS?

Presented by

Juan Rivera – WA6HTP

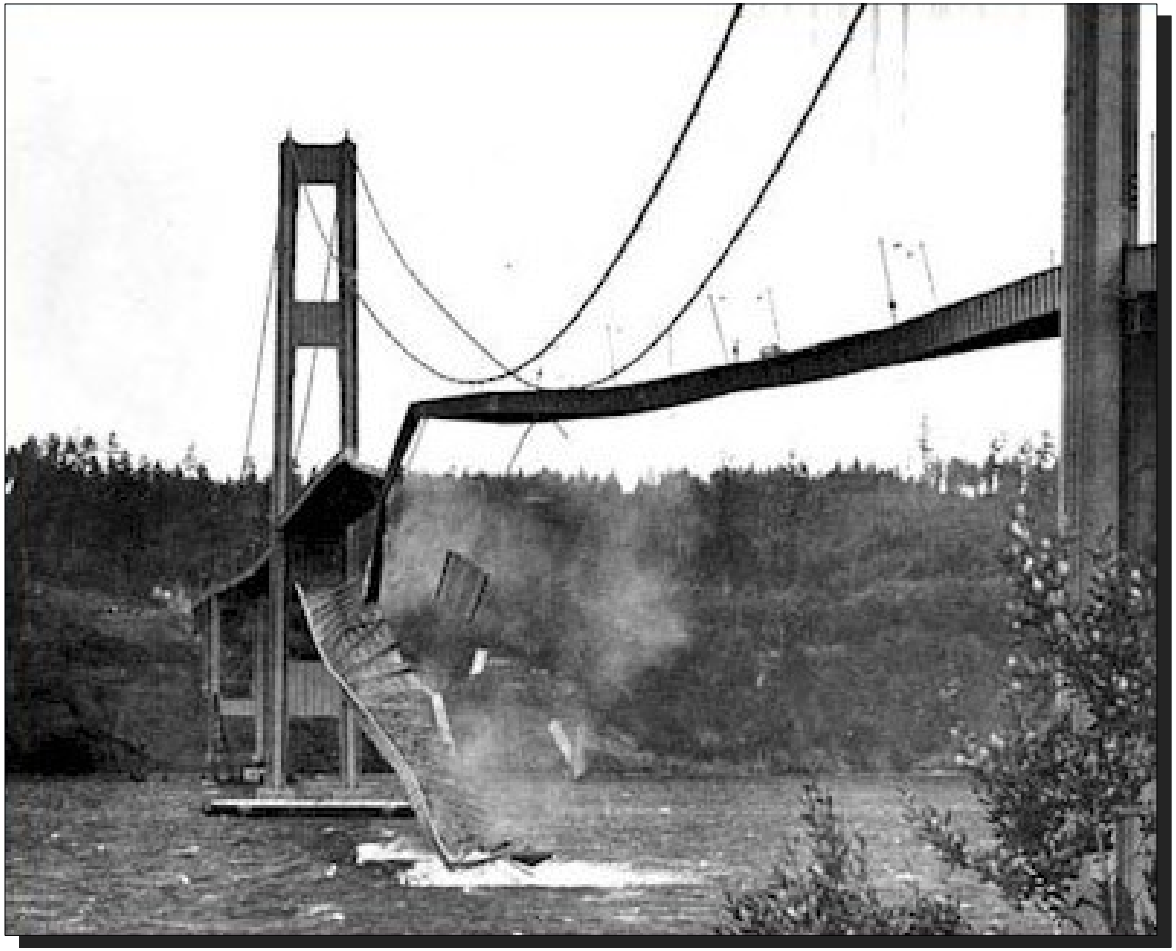
Careful Attention to Detail !

Don't Assume Anything



- Times Change
  - Old TTL ICs were very reliable.
  - That doesn't mean all modern SMT plastic ICs are equally reliable.

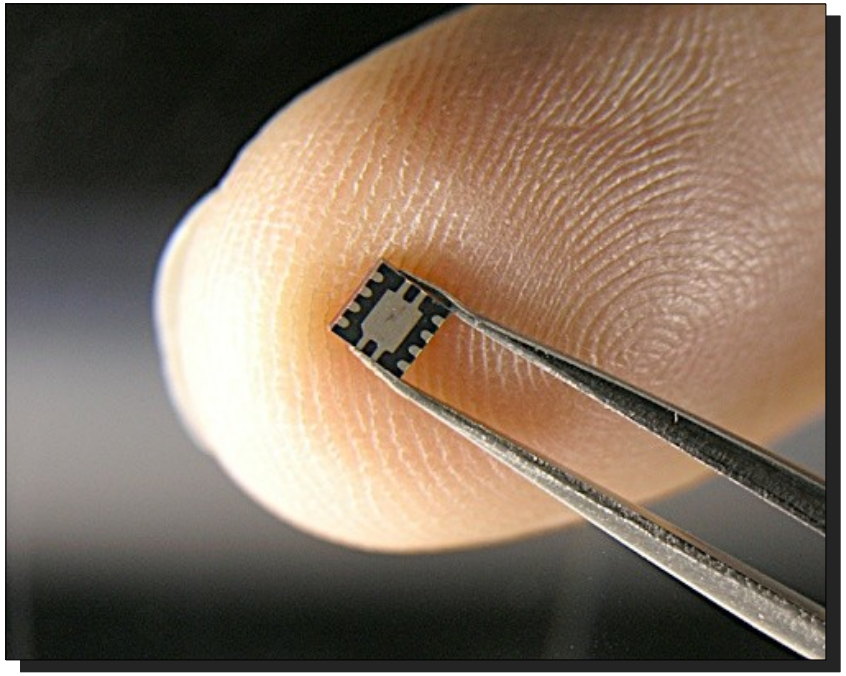
Complacency Will Bite You



SMT

- Handling
  - EOS and ESD
  - PCB Flex
- Plastic Encapsulated Microcircuits (PEM’s)
  - Moisture Sensitivity Level (MSL)
  - Popcorn Cracking
- Design
  - CTE Mismatch
  - RoHS

SMT Characteristics



- Leadless Devices
  - Cannot Absorb Stress
- Buried Contacts
  - Soldering Iron Won’t Work

SMT Failure Modes

- Electrical Damage
  - ESD and EOS
- PEM Damage
  - Popcorn Cracking / Galvanic Corrosion
- Thermal Damage
  - CTE Mismatch
- Mechanical Damage
  - Post Soldering Handling

ESD

ESD

- Electrostatic Discharge
  - Triboelectric Series
  - Typical Electrostatic Voltages
  - ESD Models and Classes
  - Categories of ESD Damage
    - Catastrophic
    - Latent **VERY BAD!!!!!!**
  - ESD Prevention

PREVENT LATENT DEFECTS !!

Triboelectric Series

Most Positive ++	Cotton	Brass	Polyurethane
Human Hand	Wood	Synthetic Rubber	Polypropylene
Glass	Lucite	Gold	PVC (Vinyl)
Human Hair	Hard Rubber	Acetate	Kel-F (PCTFE)
Nylon	Mylar	Polyester	Silicon
Wool	Nickel	Polystyrene	Teflon
Aluminum	Copper	Acrylic	Silicon Rubber
Paper	Silver	Cellophane Tape	Most Negative - -

MIL-STD-1686 ESD Classes

- Class 1: 0 – 1,999 Volts
  - < 100 Volts can Cause Damage to PEM's
    - PE3236: 1,000 V
    - DS4000: 1,500 V
- Class 2: 2,000 – 3,999 Volts
    - TPS715: 2,000 V
- Class 3: 4,000 – 15,999 Volts

Peregrine PE3236 PLL

Peregrine Semiconductor

Table 4. ESD Ratings

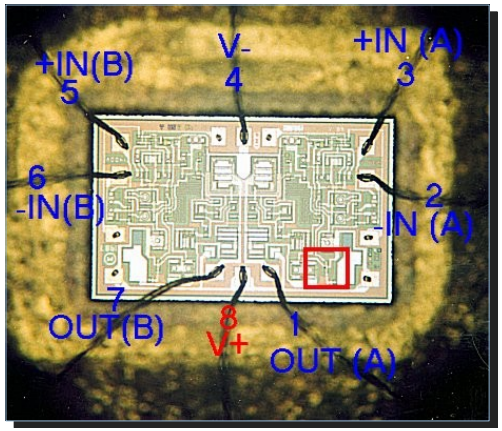
Symbol	Parameter/Conditions	Level	Units
V_{ESD}	ESD voltage (Human Body Model)	1000	V

Note 1: Periodically sampled, not 100% tested. Tested per MIL-STD-883, M3015 C2

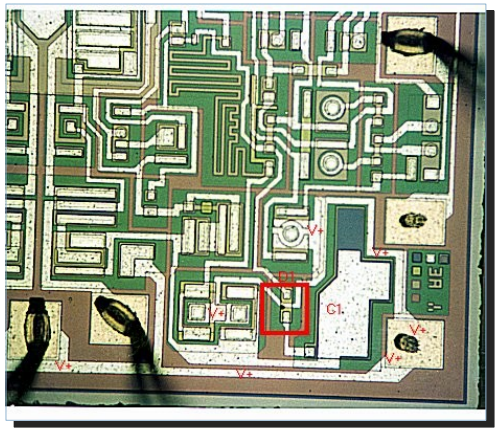
Typical Electrostatic Voltages

Means of Static Generation	Electrostatic Voltages	
	10 to 20 % Relative Humidity	65 to 90 % Relative Humidity
Walking Across Carpet	35,000 Volts	1,500 Volts
Walking on Vinyl Floor	12,000 Volts	250 Volts
Worker at Bench	6,000 Volts	100 Volts
Vinyl Envelope	7,000 Volts	600 Volts
Pick up Common Poly Bag From Bench	20,000 Volts	1,200 Volts
Work Chair Padded with Polyurethane Foam	18,000 Volts	1,500 Volts

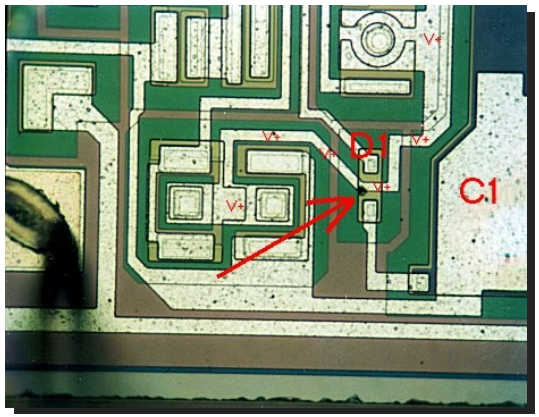
ESD Damage Latent Defects



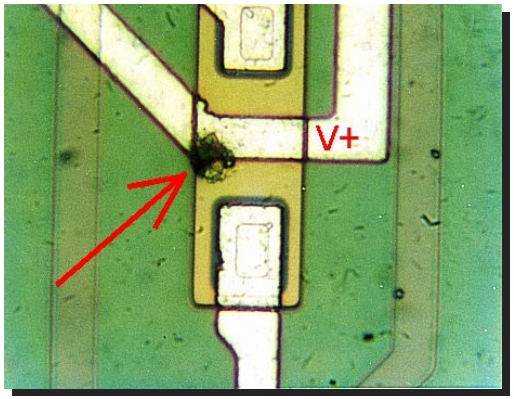
25X



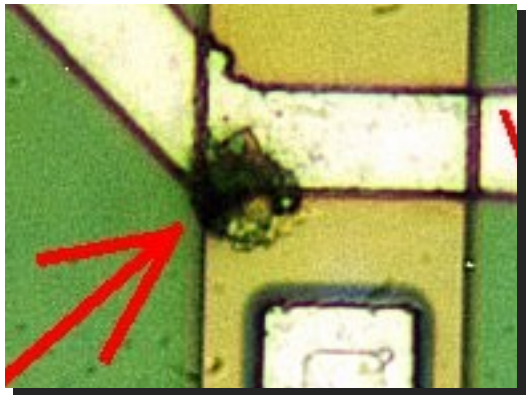
100X



200X

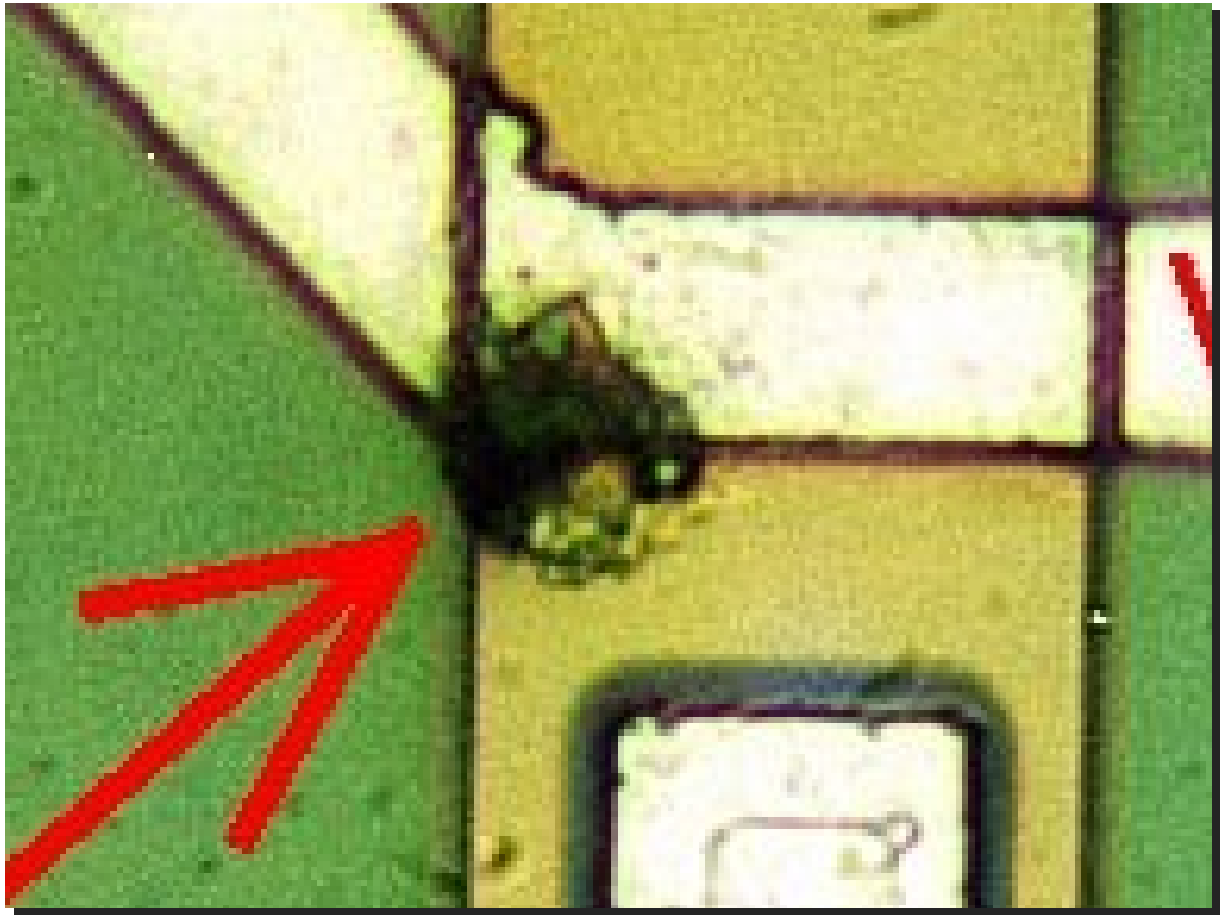


400X



1000X

ESD Damage Latent Defects



1000X

EOS & ESD Prevention

- The “Touch” Rule
  - Always keep ESD sensitive devices in a Metalized Shielding Bag
  - Avoid synthetic and wool clothing – Cotton is best
  - Avoid any unnecessary movement
  - Always touch the ESD poly bag before touching the device
  - When handling a ESD sensitive device always make contact with the bench or equipment with your hand first and not with the device

PEMs

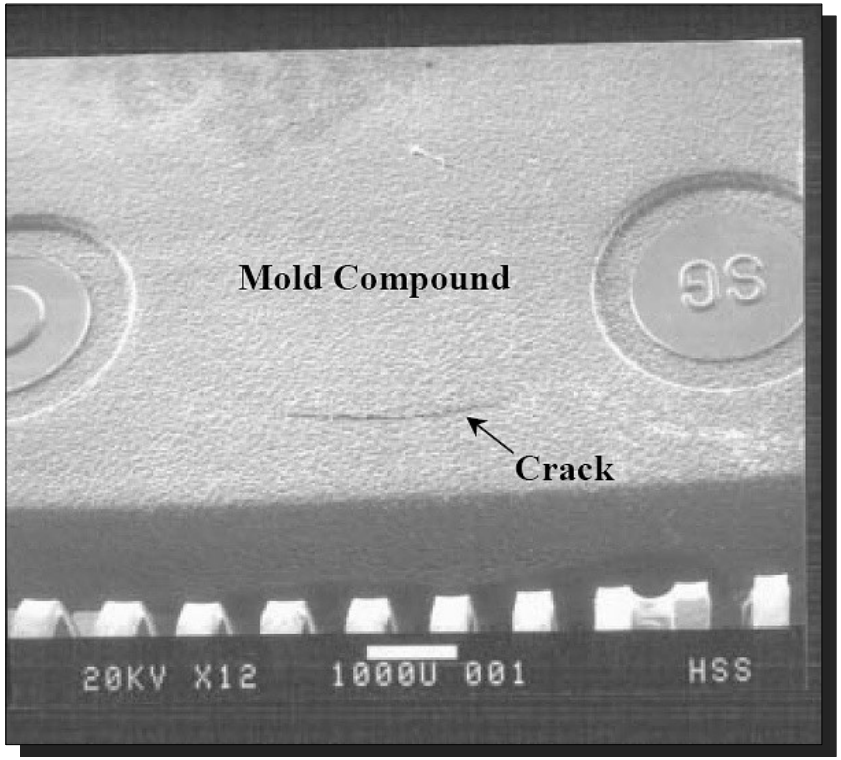
Plastic Encapsulated Microcircuits

- PEMs
  - Relatively Short Design Life
  - Quality Can Vary
  - Can Deteriorate Over Time
  - Unique Failure Modes

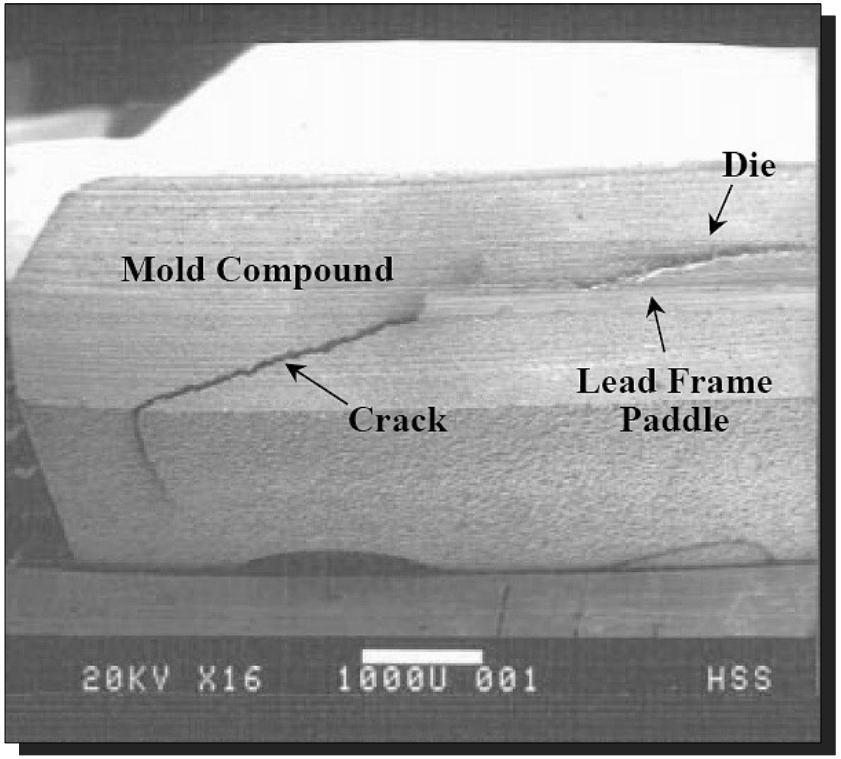
Popcorn Cracking

- SMDs subjected to reflow temperatures are susceptible to cracking and delamination of mold compound
- Temperatures create sudden vaporization of absorbed moisture
- Cracking creates path for ingress of moisture and contaminants
- This is an industry wide problem
- Solution is to dry-pack PEMs

Popcorn Cracking

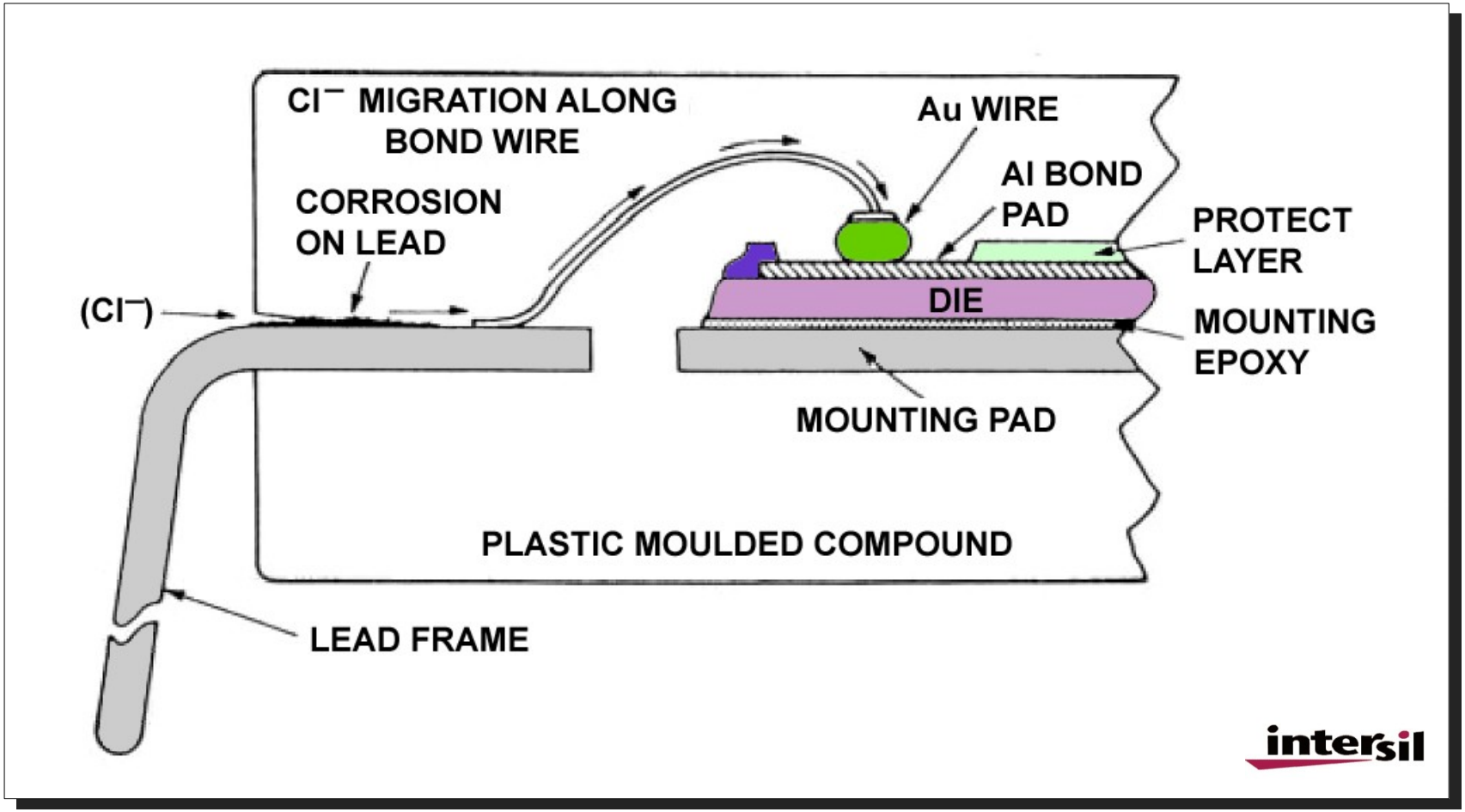


Cracks on External Package Surface



Cross-Section of Crack Propagation

Ingress of Ions and Moisture



Moisture Sensitivity Level (MSL)

JESD22 – A112 Moisture Sensitivity Levels		
Level	Dry Pack Req'd	Floor Life After Removal From Dry Pack [1]
1	No	Unlimited
2	Yes	1 Year
3	Yes	168 Hours
4 [2]	Yes	72 Hours
5	Yes	24 Hours
6	Yes	6 Hours

1: @ 30ºC / 60% RH
2: DS4000 is MSL 4

Moisture Sensitivity Level (MSL)

PE3236
Product Specification

Peregrine Semiconductor

Handling Requirements

All surface mount products which do not meet Level 1 moisture sensitivity requirements are processed through dry bake and pack procedure. The necessary data is recorded on the caution label of each shipment. The 44-lead PLCC package is moisture sensitivity Level 3.

Level 3 Caution Label

The caution label should contain the following information for Level 3 devices:

1. Calculated shelf life in sealed bag: 12 months at <40 °C and <90% relative humidity (RH)
2. Peak package body temperature is 225 °C.
3. After bag is opened, devices that will be subjected to reflow solder or other high temperature process must
   a) Be mounted within 168 hours of factory conditions <30 °C/60% RH, **or**
   b) Be stored at <10% RH
4. Devices require bake, before mounting, if:
   a) Humidity Indicator Card is > 10% when read at 23 ± 5 °C
   b) 3a or 3b are not met
5. If baking is required, devices may be baked for 48 hours at 125 +5/-0 °C

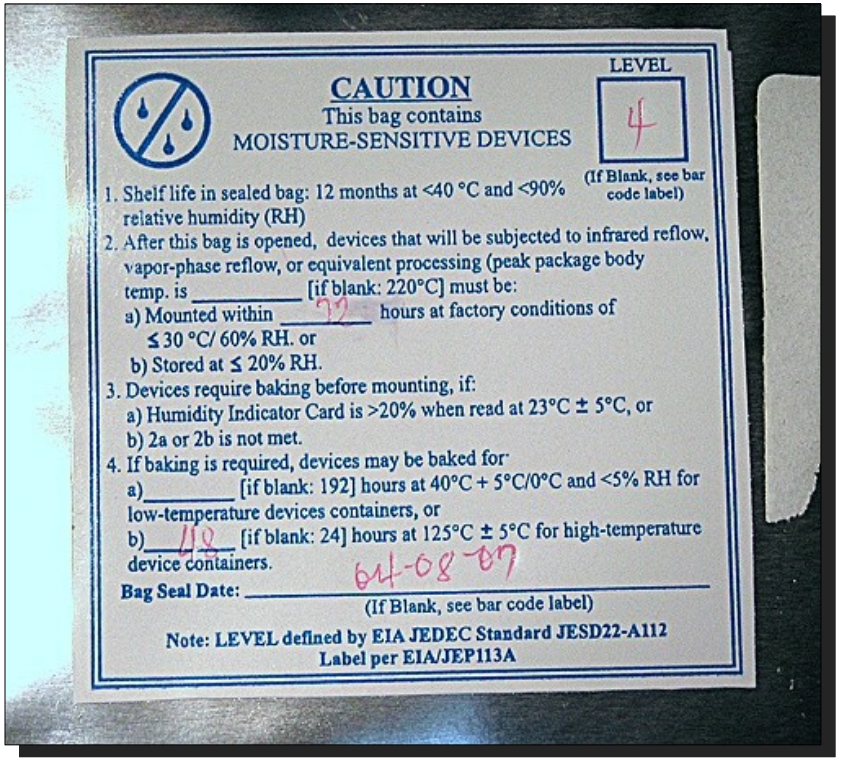
Note: If device containers cannot be subjected to high temperature or shorter bake times are desired, reference IPC/JEDEC-J-STD-033 for bake procedure.

Level and Body temperature defined by: IPC/JEDEC-J-STD-020

For Dry Bake Procedures, see: IPC/JEDEC-J-STD-033

Operator must observe ESD precautions per ESD Control Procedure and Parts Handling and shipping Procedure.

Dry Pack


CAUTION
This bag contains
MOISTURE-SENSENSITIVE DEVICES
LEVEL
4
(If Blank, see bar code label)
1. Shelf life in sealed bag: 12 months at <40 °C and <90% relative humidity (RH)
2. After this bag is opened, devices that will be subjected to infrared reflow, vapor-phase reflow, or equivalent processing (peak package body temp. is _____ [if blank: 220°C] must be:
a) Mounted within 72 hours at factory conditions of ≤ 30 °C/ 60% RH. or
b) Stored at ≤ 20% RH.
3. Devices require baking before mounting, if:
a) Humidity Indicator Card is >20% when read at 23°C ± 5°C, or
b) 2a or 2b is not met.
4. If baking is required, devices may be baked for:
a)_____ [if blank: 192] hours at 40°C + 5°C/0°C and <5% RH for low-temperature devices containers, or
b) 48 [if blank: 24] hours at 125°C ± 5°C for high-temperature device containers.
Bag Seal Date: 04-08-07
(If Blank, see bar code label)
Note: LEVEL defined by EIA JEDEC Standard JESD22-A112
Label per EIA/JEP113A

Keep moisture sensitive devices in
Their dry packs until reflow time.

CTE Mismatch

Coefficient of Thermal Expansion (CTE)

Materials

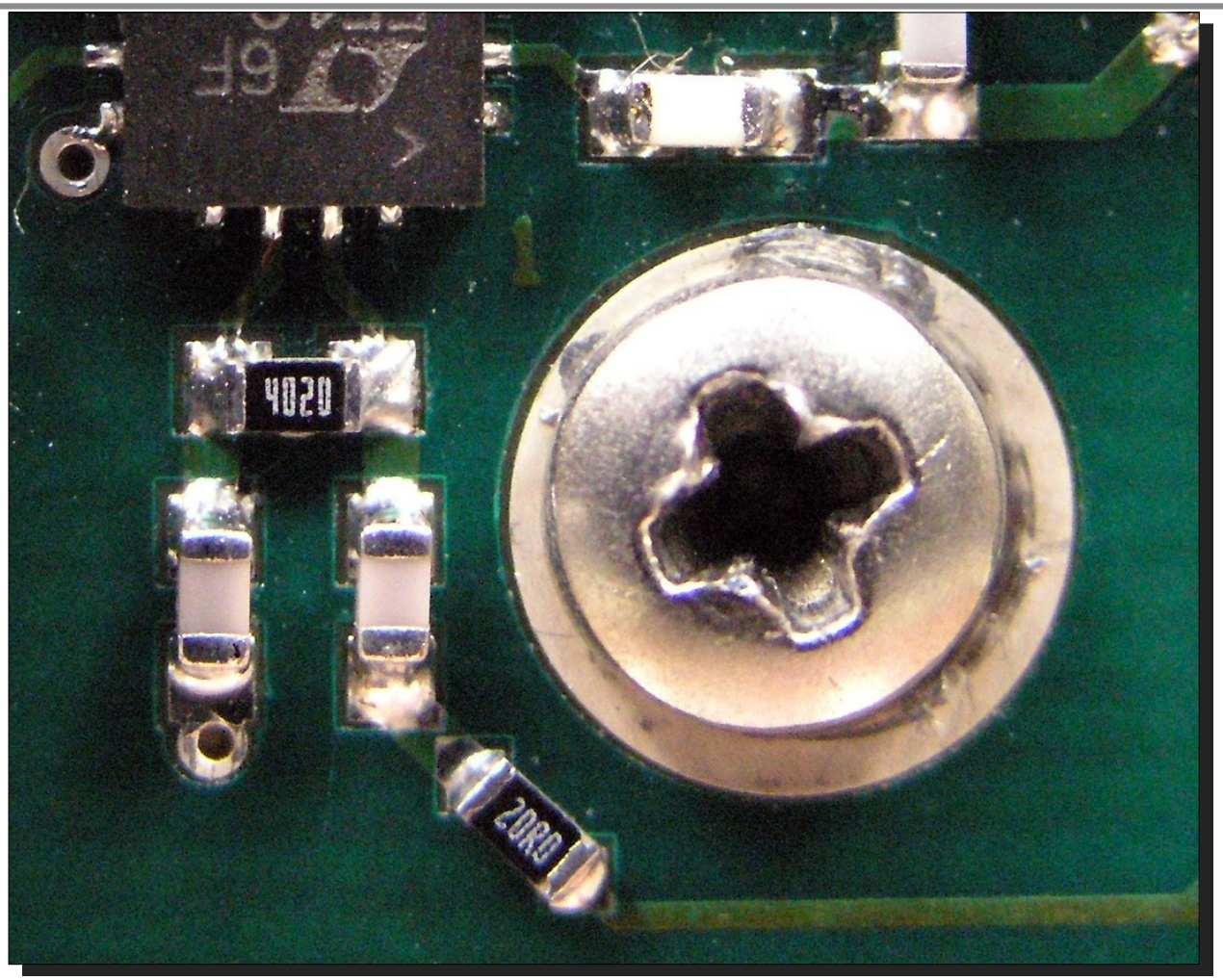
Material	CTE (ppm / ^{0}C
Chip Capacitor	9.5 – 11.5
Chip Resistor	≈ 7
Copper	17.6
FR4 PC Board (X<Y)	≈ 18
Filled Epoxy (<Tg)	18 - 25
Kovar	5.3
Sn/Pb Alloy (Solder)	≈ 27
Aluminum	23

Plastic Encapsulated

PEM Material	CTE (ppm / ^{0}C
Chip Silicon	3.5
Chip Oxide	8 - 10
Chip Aluminum	23.8
Leadframe (Alloy 42)	5.0
Leadframe (Copper)	16.9
Gold Wire	14.3
Die Attach Material	40 - 70
Mold Compounds	7.5 - 28

Data courtesy of AVX Corporation and Intersil

70 cm Receiver CTE Issues



Minimum PCB Bend Radius

- AVX Corp recommends a minimum bend radius of 60 inches to eliminated damage for a broad range of SMT devices.
- This allows only 0.0084” deflection over any 1-inch board segment.
- Avoid board edges, areas around connectors, or mounting screws since they are areas of high deflection and stress.

RoHS

- Reduction of Hazardous Substances (RoHS)
  - Often Contacts Are Plated with Pure Tin
  - Higher Melting Point
    - Additional Stress to Components

Tin Whiskers

- Spontaneous growth of conductive tin filaments from pure tin platted surfaces
  - Responsible for the on-orbit destruction of several commercial communication satellites at the cost of hundreds of millions of dollars
  - Pure tin is banned by the military, NASA, and commercial satellite manufacturers
  - RoHS components may be plated with pure tin

Tin Whiskers

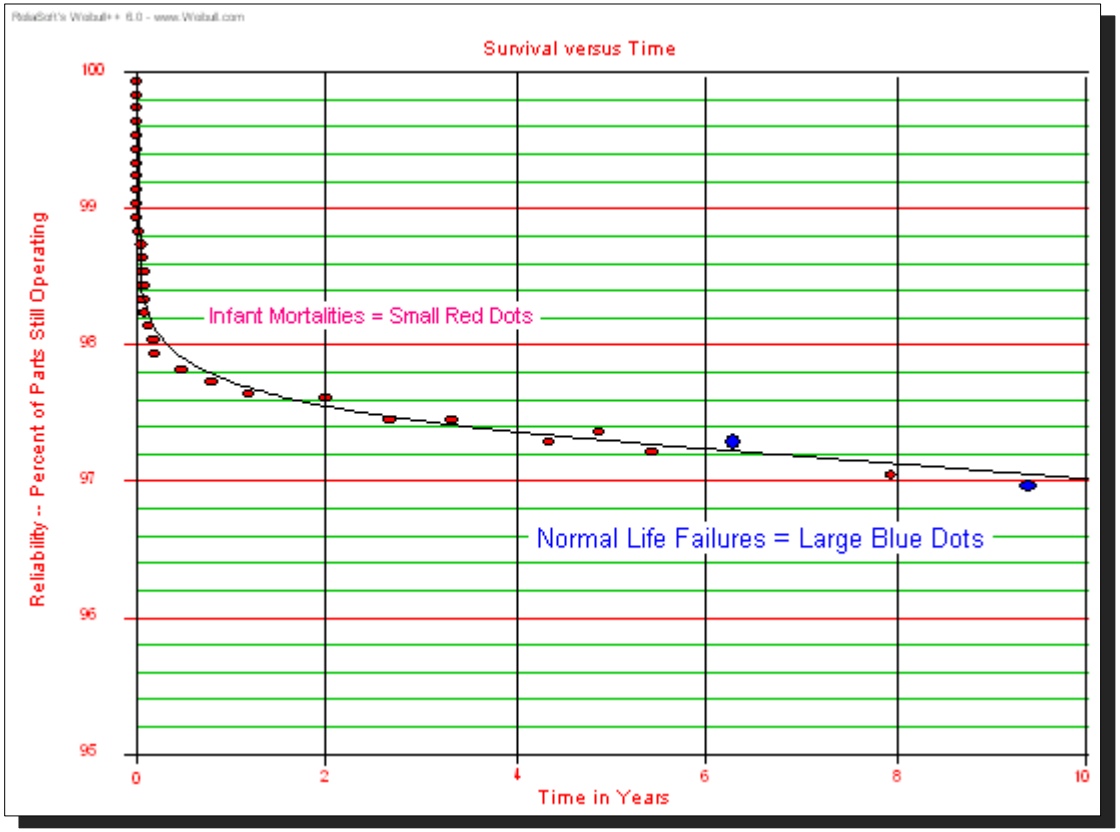
Part Selection

- Derate Your Components !
  - Radiation will Degrade Performance and Reliability
- Use Top Tier Manufacturers and Suppliers
  - Consider Rad-Hard and Space-Rated parts (if You Can Get Them!)
  - Select Widest Operating Temperature Range You Can Find
  - Experience manufacturing MIL and Space Rated parts is a plus
  - Stay within the Approved Supply Chain
    - Avoid Counterfeit Parts
    - Avoid Old Parts – PEMs Can Degrade With Age

Parts Screening

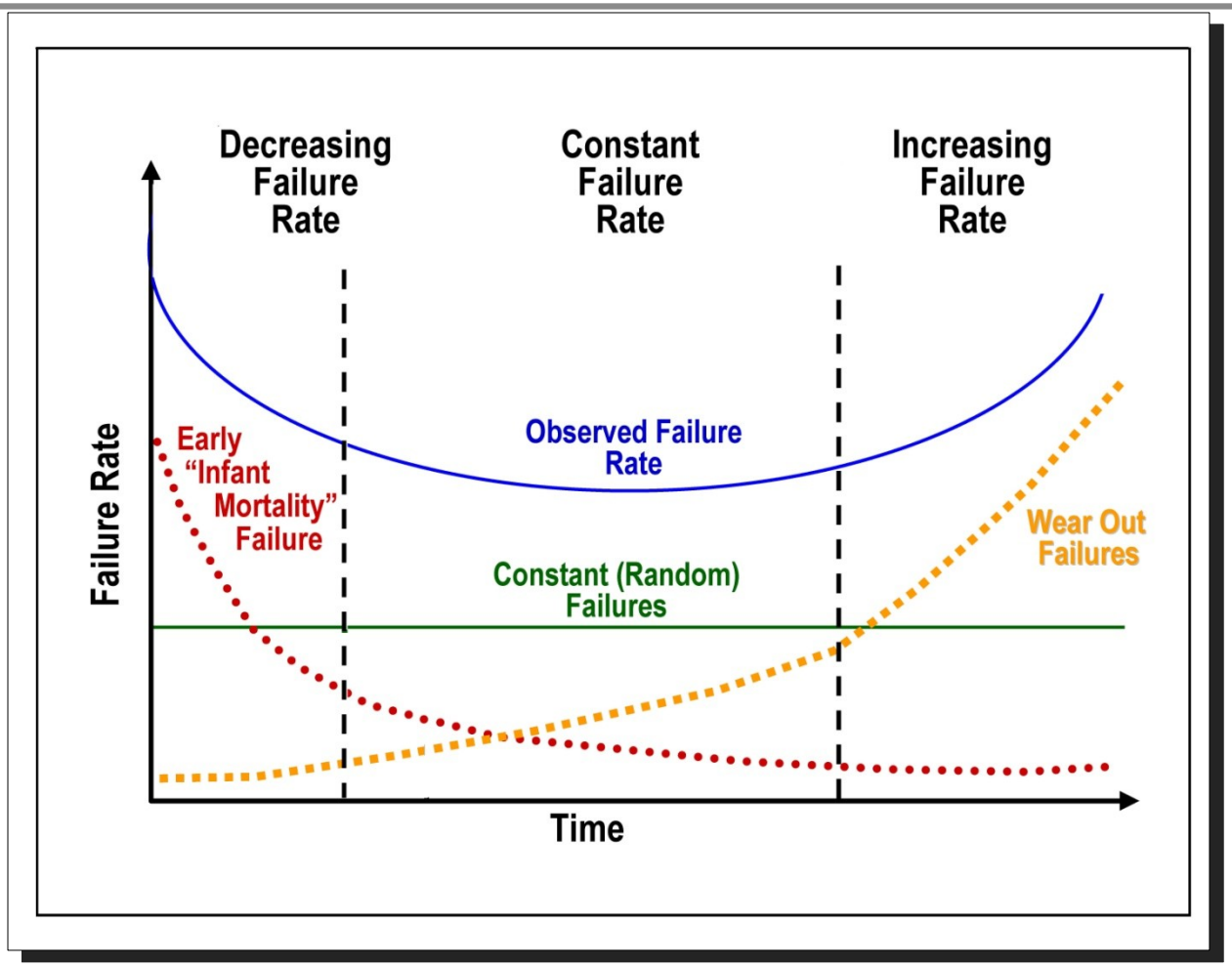
- The “Big Boys” Screen All of Their Space-Rated Parts

Semiconductor Survival Vs. Time



ReliaSoft Corporation

“Bathtub Curve”

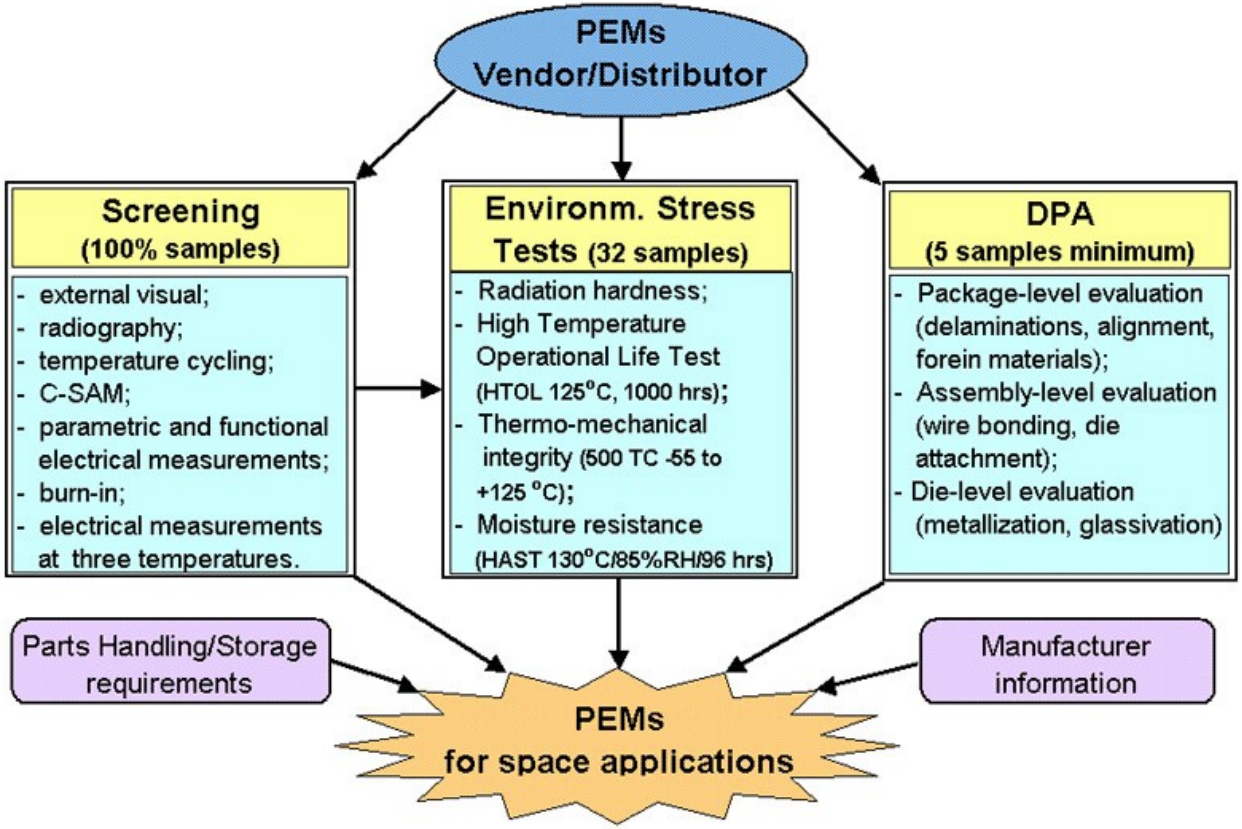


Wikipedia

Raw vs. Burned-In Parts

ReliaSoft Corporation

Simplified PEM Qualification Test Flow - It's Too Expensive !!!

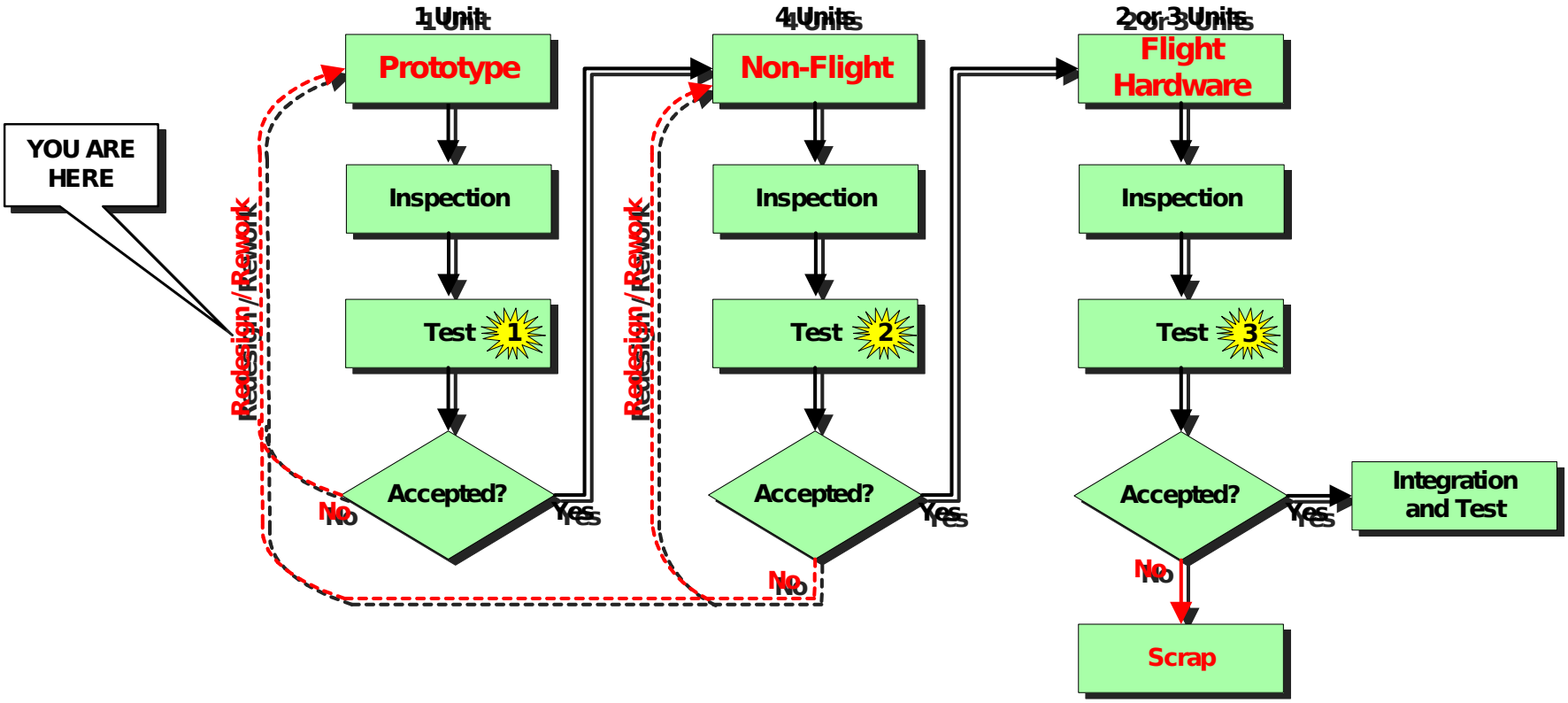


NASA Goddard Space Flight Center

The Alternative

- Conservative Design
  - Derate components and Plan for Radiation Degradation
- Board-Level Testing
  - Thermal / Vacuum Testing
  - High-Temperature Burn-In
  - Thermal Cycling
  - Acoustic / Vibration Testing
  - Radiation Testing
  - Won’t Catch Infant Mortality Failures
    - We Must Accept a Higher Level of Risk
  - Will Catch Most Manufacturing Defects

Project Life Cycle



Prototype Testing

- Does the Thing Work ??
  - Functional Testing
  - Focused Testing / Troubleshooting / Rework
  - ATP (Does it Meet Requirements?)
  - Burn-In
  - Accelerated Stress Testing
  - ATP (Did Anything Change?)

Non-Flight Testing

- Are Our Processes Sound?
- Is the Design Reliable?
  - ATP (Establish a Baseline)
  - Burn-In
  - Acoustic / Vibration
  - Thermal / Vacuum
  - Accelerated Stress Testing
  - Radiation
  - ATP (Did Anything Change?)

Flight Hardware Testing

- Is This Particular Receiver Reliable?
  - Only Enough Testing To Insure Reliability
    - ATP (Establish Baseline and Determine Functionality)
    - Burn-In
    - Limited Temperature Cycling
    - Acoustic / Vibration
    - ATP (Did Anything Change?)

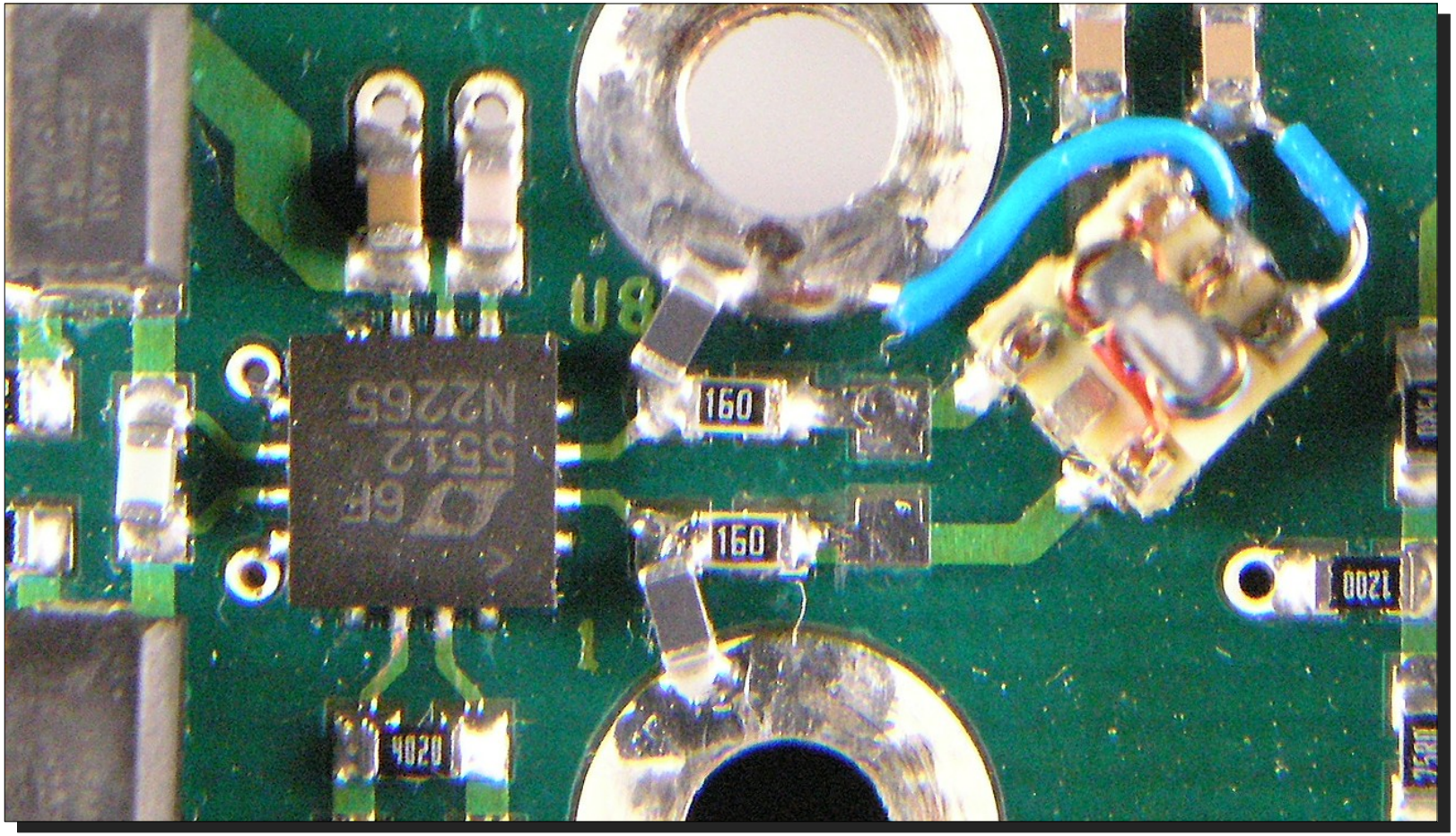
SMT Rework

Abandon hope all ye who enter here...

SMT Failure Modes Revisited

- Thermal Damage
  - Thermal Shock **(Soldering Irons!)**
  - Overheating
    - **Rework/Repair is most common cause of overheating**
- Electrical Damage
  - **ESD**
- Mechanical Damage
  - **Post Soldering Handling**
    - PCB Warping or Bending
      - Component Cracking
  - **PEM Damage**
    - Popcorn Cracking / Galvanic Corrosion
      - **Moisture Absorption**

SMT Rework



SMT Rework Equipment

SMT Rework Equipment

Howard
Electronic
Instruments Inc.

SMT Rework Equipment

SMT Rework Equipment

METCAL

Questions & Answers

The End

juan-rivera@sbcglobal.net